RFI Measurement Survey at Goldstone in November and December 1981

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TDA Mission Support

The participation of Deep Space Network personnel in support of a measurement survey contracted with the Institute of Telecommunication Science is reported. The survey took place at Goldstone, California, in November and December 1981 and measures the emissions from the transmitters at Deep Space Station 14 and the Spaceflight Tracking and Data Network station.

I. Introduction

This survey was commissioned in order to inform the Deep Space Network (DSN) managers about the emissions, both intended and spurious, from DSN operational transmitters and about the quiescent (no DSN transmitters operating) electromagnetic environment at the Deep Space Communications Complex, Goldstone, California. The opportunity was taken to gather information about the emissions from the Spaceflight Tracking and Data Network (STDN) transmitters at the Apollo site at Goldstone and to compare the Institute of Telecommunications Science (ITS) survey van sensitivity with the operational Radio Spectrum Surveillance Station (RS3) at Goldstone. The timing of the survey was driven by two considerations: (1) the desirability of completing the measurements before the Army's National Training Center at Fort Irwin and the Air Force's Superior Valley Electronic Warfare Range became operational in late January 1982 and (2) the availability of the Radio Spectrum Measurement System (RSMS) van from ITS at Boulder, Colorado.

II. Preparation

A team was formed at Jet Propulsion Laboratory and Goldstone to support this task. The team organization chart is Fig. 1. A technical plan was drawn up (appendix) and furnished to ITS.

Mr. R. J. Matheson is the lead engineer in ITS responsible for the operations of the RSMS van. Working in concert with Mr. Matheson, the team honed the plan from desirables to practicables; the availability of the RSMS van was defined as being November 9, 1981, onwards and the period of observations was refined to five weeks. It was explained in detail to ITS that the nature of DSN and STDN operations and scheduling would leave no room for error – that is, transmitter measurements would have to be made during a specific, prescheduled time frame at both DSS 14 and the Apollo site.

The variables in the schedule from the network viewpoint were identified as (1) the second orbital flight test of the Space Transportation System (Space Shuttle) and (2) engineering maintenance work at DSS 14. As things transpired, the Space Shuttle's second flight was delayed by a week and, fortunately, DSS 14 was made inoperative from 5 October to 7 December for engineering repairs to be effected on the elevation drive gearboxes. This enforced inoperability of DSS 14 allowed for a long period of time during which schedules of transmitter on/off times could be adjusted to allow for possible problems with the ITS van or any other unforeseen circumstances which might have arisen. This was, then, a positive bonus in flexibility to the whole measurement program. A schedule (Fig. 2) was drawn up, in concert with ITS, to take advantage of this flexibility.

From the technical plan, ITS and Section 331 of JPL were requested to interface and organize some preparatory hardware and software to enable the RFI Surveillance System of the Advanced Technology program to be utilized in support of these measurements to produce a finer resolution and, hence, a higher order of sensitivity to the measurements.

III. Operation

The observations, originally planned to commence on November 10, were delayed due to software and hardware problems arising in the ITS van and did not get under way until December 1, 1981. At a meeting on November 23 to discuss the scheduling difficulties caused by the inoperability of the RSMS van, it was agreed that the measurements would be rescheduled as shown in Fig. 3.

The measurements were, in fact, conducted at DSS 14 in a somewhat "piecemeal" fashion; that is to say that because the station had to become operational on December 7 and the measurements could not start before December 1 and pre-operational system performance tests had to be performed prior to tracking support commencement, some tests had to be performed at odd hours (non-daytime) and with low priority (NIB 3). Tests had to be shortened to exclude all but the *essential* elements and some tests were even postponed.

The measurements at STDN and the GOSR (Goldstone Operational Surveillance Radar) Hill seemed to go very well, although the ITS van sensitivity was questioned because of its inability to detect the test transmitter at DSS 11, without reconfiguration, from GOSR Hill. An offer was made by ITS, and accepted by JPL, for the van to return to Goldstone in March 1982 to finish measurements not completed in the initial visit.

IV. Comments

This section represents an amalgam of the observations and comments of the several support team members at the conclusion of the ITS van survey.

The funding to ITS for the measurement was to be applied in three parts: (1) $40,000 in FY 81 for hardware and software preparation and planning, (2) $35,000 in FY 82 for the field measurements, and (3) $15,000 in FY 82 for the analysis and report writing.

Technical comments included the following: (1) lack of preventive maintenance of the van resulted in its breakdown; (2) lack of planning and preparation resulted in the inability to repeatedly survey the 2290-2300 MHz band without covering the whole "superband" 2000-3580 MHz; (3) the inaccuracy of the least significant (MHz) digit of the remote receiver center frequency readout provided to the RFI surveillance system; and (4) the failure of the IF from the ITS van to perform within advertised limits (±3 dB within any superband). Many spurs were noticed in this IF when examined with the higher resolution of the RFI trailer.

A comment on personnel management must mention the fact that many crew changes resulted in a noticeable lack of continuity due, in part, to the average skills "mix" being definitely biased toward software and away from RF and hardware. General impressions were that this preponderance of software experience has, over a number of years, led to the use of many workarounds and fixes which may be disguising some basic RF and IF hardware problems.

Despite the above it was felt that the personnel involved in the measurements were adaptive, creative and very willing to cooperate to ensure the success of this program. Their dedication and flexibility is very much appreciated and respected.

Some of the findings which raise interesting questions are (1) there is an apparent 20 dB or so difference in received signal strength at DSS 14 for different azimuths, and (2) apparently the high power (400 kW) S-band transmitter is "cleaner" than the DSN (20 kW) transmitter in the range 1-4 GHz.

One very successful feature of these tests was the utilization of the RFI surveillance system trailer at DSS 14. The trailer was in situ awaiting the arrival of the ITS van prior to November 10, having already accomplished a 6-day environmental search of S-band. Throughout the duration of this survey the trailer proved to be very reliable (one recorder failed for two days) and very operable. The hope is that this instrument will be available in the future when other RFI tests are scheduled to be performed.

Finally it seems that, despite several problems of a technical nature, the whole measurement has been worthwhile and will yield important information about transmitter emissions and the Goldstone environment. The total success of the venture will be assured by the upcoming analyses at JPL and ITS.

Acknowledgment

The following personnel are commended for their efforts in behalf of this program:

P. E. Beyer, Performance Analysis Group, JPL
D. R. Hersey, Spectrum Engineering Group, JPL
M. J. Grimm, Digital Projects Group, JPL
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T. R. Tesarek, High Power Transmitter Maintenance Group, Goldstone
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C. A. Kodak, DSN Radio Astronomy Unit, Goldstone
R. J. McConahy, DSN Radio Astronomy Unit, Goldstone
J. McCoy, Maintenance and Integration Group, Goldstone
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A. Danessa, GSFC
Personnel of the scheduling department of the STDN at GSFC
Station operations personnel of the DSS 14 (Mars) station, Goldstone
Station operations personnel of the STDN (Apollo) station, Goldstone

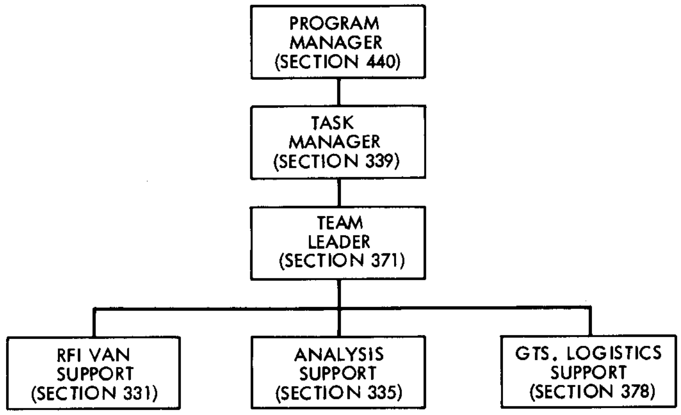

Fig. 1. JPL organization chart for RFI measurement task

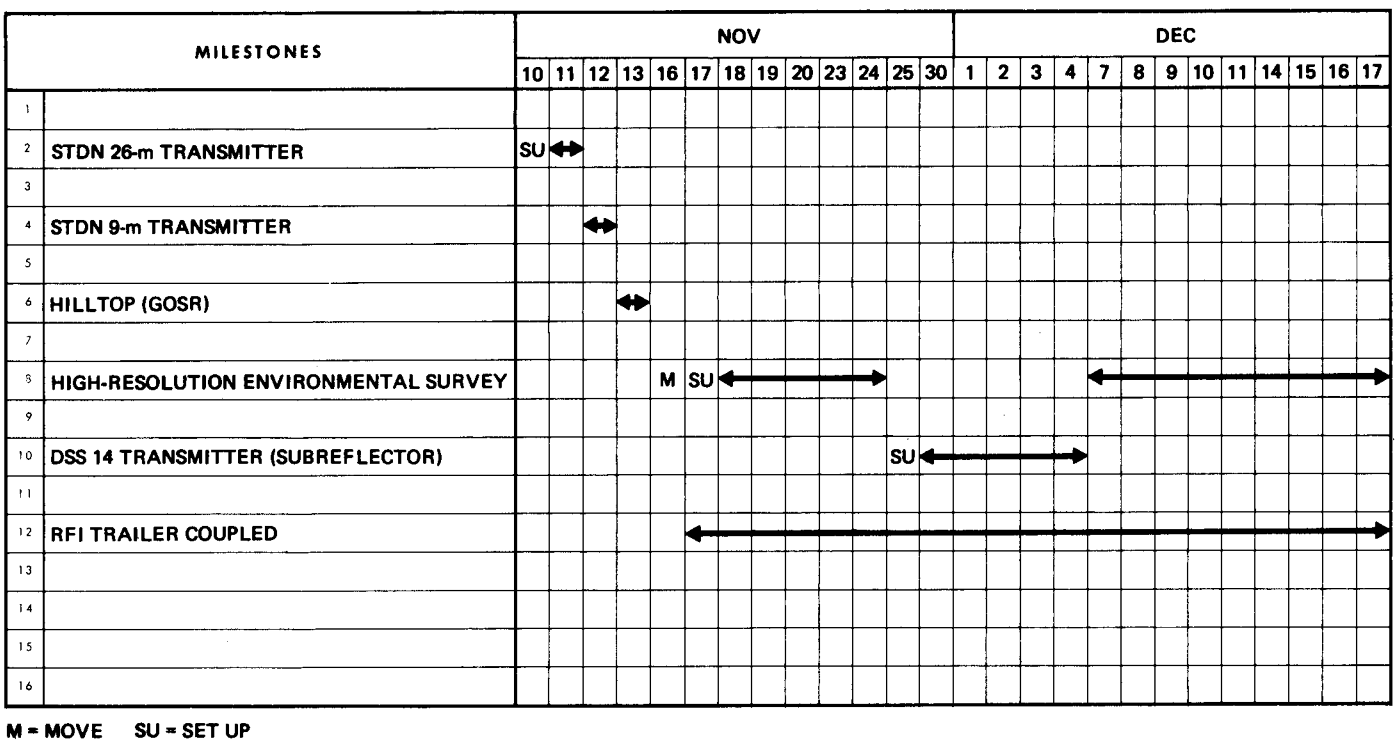

Fig. 2. ITS van survey schedule, Goldstone 1981

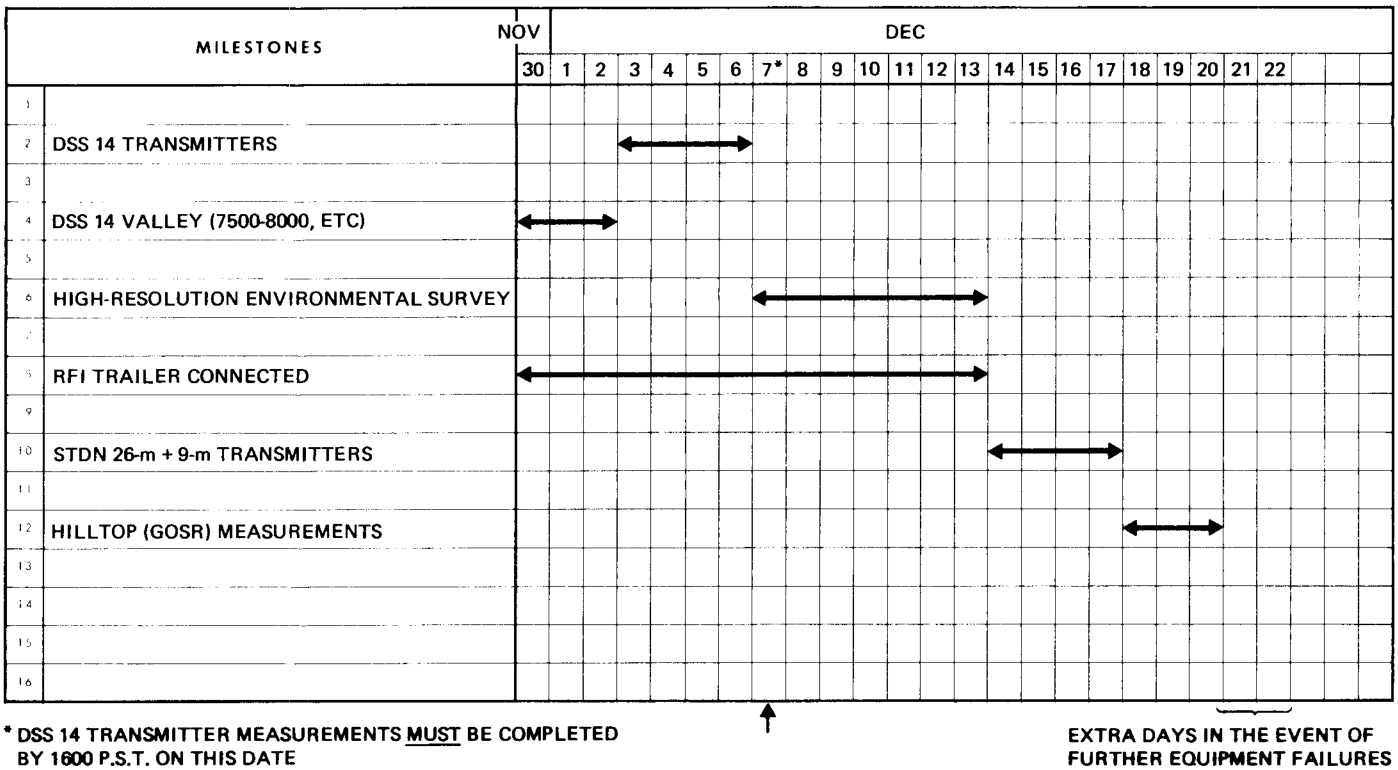

Fig. 3. Revised ITS van survey schedule, Goldstone 1981

Appendix

Test Plan: Goldstone Transmitter Emissions and Radio Frequency Environment Measurements

I. Introduction

This plan describes radio frequency measurements to be performed at the Goldstone Station Complex from the period of November 10 to December 17, 1981. The objectives of these measurements are to identify and quantify spurious emissions of the transmitters at DSS 14 and the Apollo station and to measure the ambient radio environments at DSS 14 and the Goldstone radar site. The information gained from these measurements will be used to assess the interference potential of the NASA stations to other stations operating in the Goldstone area, to verify assumptions made in estimating the RFI potential of colocating antennas as planned for the Network Consolidation Program and to better understand the Goldstone radio frequency environment.

II. Test Description

The Department of Commerce Radio Frequency Measurement System (RSMS van) is required for all measurements. The JPL RFI van is to be used in conjunction with the RSMS van at DSS 14 to gain additional sensitivity. (Ideally, both vans would be used for all measurements; however, due to the time required for moving and preparing the RFI van it will only be possible to operate the two vans together at DSS 14).

III. Apollo Station Transmitter Emissions

The purpose of these measurements is to measure the emissions from the Apollo station transmitters in order to provide emission characteristics to other Goldstone users. The RSMS van will be located 200 meters from the 9-meter and 26-meter antennas. A different location for the van will be required for each station antenna. The station antenna under test will point in azimuth at the van and as close as possible in elevation to the RSMS van's antenna.

WARNING

RADIATION LEVELS HAZARDOUS TO PERSONNEL ARE PRESENT WITHIN THE NEAR-FIELD TUBES OF THE STATION ANTENNAS. AT NO TIME MUST THE RSMS VAN OR PERSONNEL BE IN THE NEAR-FIELD TUBE OF A STATION ANTENNA. THIS TUBE IS CENTERED ON THE ANTENNA BORESIGHT AXIS AND HAS A DIAMETER EQUAL TO THE DIAMETER OF THE ANTENNA.

The RSMS van will perform measurements over a 1- to 12-GHz frequency range with each antenna operated at 1 kW with normal ranging modulation. The transmitter center frequency shall be approximately 2105 MHz; the major ranging tone shall be 500 kHz with a modulation index of 0.7 radian, peak. The minor ranging tone (4 kHz) shall have the same modulation index and be modulated with the normal range ambiguity resolving frequencies.

The RSMS van detection threshold (peak detection) for frequencies from 1 to 12 GHz shall be –97 dBm/m^2 or lower except for frequencies from 2290 to 2300 MHz and 8400 to 8450 MHz, which shall be –116 dBm/m^2 or lower. The expected received spectra are shown in Fig. A-1.

IV. Goldstone Radar Site

The purpose of these measurements is to measure the ambient radio environment at a site which has large coverage of the Goldstone complex. If a signal measured from this location is also measured at the DSS 14 or Apollo station site an estimate of site shielding at these sites can be made.

The RSMS van will be located near the Goldstone radar facility and will perform a 360-degree horizon scan with a detection threshold of –109 dBm/m^2 or lower over the frequency range of 2200 to 2300 MHz. At one azimuth (to be specified) the RSMS van will perform a 1- to 12-GHz search with a detection sensitivity of –97 dBm/m^2 or better.

A comparison of indicated frequencies and received signal levels indicated by the RSMS van and Radio Spectrum Surveillance Station (RS^3) for at least one airborne source and the RS^3 test source shall be made.

V. Measurements at DSS 14

The measurements to be performed at DSS 14 are measurements of emissions from each of the station's transmitters and measurements of the DSS 14 radio environment with the station transmitter off. The purposes of the transmitter emission measurements are to identify spurious transmitter emissions which may interfere with future colocated stations and to obtain emission characteristics needed for frequency coordination with other agencies.

The measurements of the ambient radio environment will be performed with high-frequency resolution and sensitivity to determine the operating environment of the station. This information is needed for frequency coordination activities and to aid in the design of future DSN equipment.

The measurements will be performed using the RSMS van and RFI van operating together. The RSMS van will be located approximately 405 feet from the center of the base of DSS 14's antenna and as close as possible to the RFI van, which will be located approximately 100 feet east of the control building (see Fig. A-2).

The exact location of the RSMS van shall be selected by maximizing the signal level received at the van when the van's antenna is directed along a line from the center of the DSS 14 antenna subreflector to the edge of the antenna reflector, with the 20-kW S-band transmitter on and the station antenna in the stowed position. The maximum calculated radiation level at this location (with a 400-kW transmitter) is -14 dBm/cm^2, so there is no hazard to personnel working in this location (0 dBm/cm^2 or higher is considered hazardous by JPL).

The interconnections of the vans shall provide:

(1) A 330-MHz IF signal from the RSMS van receiver to the RFI van (3 dB bandwidth of 20 MHz).

(2) An interrupt signal supplied from the RSMS van to initiate RFI van signal processing. This interrupt will occur after each 20 MHz frequency change of the RSMS van receiver center frequency.

(3) An inhibit signal supplied by the RFI van to the RSMS van to inhibit changing the RSMS van receiver center frequency.

(4) Digital signals for displaying the RSMS receiver center frequency in the RFI van (four most significant digits).

(5) A voice communication link.

Using the described configuration and with the RSMS antenna directed at the DSS 14 subreflector, both vans shall measure the emissions of the DSS 14 transmitters in the frequency range of 1 to 12 GHz. The required transmitters, frequencies, and modulations are:

(1) 20 kW S-band transmitter with DRVID ranging modulation, 9-dB carrier suppression. Center frequency, 2113.3 (DSN Channel 14).

(2) 100 kW S-band transmitter same as 20-kW transmitter conditions.

(3) 400 kW S-band radar transmitter modulated with 5.1 microsecond chipwidth PN code (length 2048 bits). Center frequency, 2320 MHz.

(4) 400 kW X-band radar transmitter modulated with 5.1 microsecond chipwidth PN code. Center frequency, 8495 MHz.

Both vans will make hard copy records of the frequency and signal level of all detected signals.

The detection threshold of the RSMS van shall be -96 dBm/m^2 or lower over the range of 1 to 12 GHz except for frequencies between 2200 to 2300 MHz and 8400 to 8450 MHz. For frequencies in these ranges the detection threshold shall be -116 dBm/m^2 or lower. The detection threshold for the RFI van shall be -140 dBm/m^2 or lower for all frequencies from 1 to 12 GHz. Estimated spectra (near the carrier) for each transmitter are shown in Figs. A-3, A-4, and A-5.

The high-resolution environmental survey shall use the same configuration as for the emission measurements except that the RSMS van antenna will be pointed near the horizon and stepped 360 degrees in azimuth (time permitting). Due to limited manpower to staff the RSMS van, only the RFI van shall record the detected signals. The survey shall be made over the frequencies of 1 to 12 GHz with a detection threshold of -140 dBm/m^2 or lower.

VI. Required Support

A. Manpower

A minimum of two RSMS van operators shall be provided by the Institute of Telecommunications Sciences, Department of Commerce, for a 5-week period. A minimum of 1 RFI van operator will be provided by JPL for a 2-week period. Additional support, as required, will be provided by the DSN Radio Astronomy Unit.

Station personnel required are those necessary to operate the transmitters at DSS 14 and the transmitters and antennas at the Apollo station. Goldstone facility support personnel will be required to provide ac power and telephones for the RSMS and RFI vans. An RS^3 operator will be required for approximately 4 hours to assist in the RS^3 and RSMS comparisons.

B. Power Requirements

The RFI van requires 45-kW, 3-phase power at 208 volts at DSS 14. The RSMS van requires 30 amps at 240 volts, rms, single-phase or 208 volts, rms, three phase at DSS 14, the Goldstone Radar Facility and the Apollo station.

C. Communications

JPL will provide intercom equipment for voice communications between the RSMS van and RFI van. A telephone shall be installed in each van at DSS 14.

D. Other Support

All electrical interfaces are shown in Table A-1. All interconnecting cables between vans and the power cables will be provided by JPL except the cable providing RSMS receiver frequency information, which will be furnished with the RSMS van. Interconnecting cables between the RFI and RSMS vans shall be 120 feet long and of the following type.

RG 214 for the 330 MHz IF signal
RG 223 for the interrupt signal
RG 223 for the inhibit signal
RG 223 for voice communication

VII. Test Reports

The Institute of Telecommunications Sciences shall provide a test report describing the results of the RSMS van measurements by June 4, 1982. Copies of original hardcopy data will be supplied by JPL within 1 month of completion of the measurement. The test report shall include (1) the test configurations and pertinent system parameters, and (2) graphs of amplitude versus frequency and identification of signals where possible.

JPL Section 331 shall provide a report giving the results of the RFI van measurements within 60 days of the completion of the measurements. The report requirements are the same as in the above report.

Table A-1. Electrical interfaces

IF signal	
Center frequency:	330 MHz
Source impedance:	50 ohms
3 dB bandwidth:	⩾20 MHz
Signal level:	–50 dBm noise level
RMS to RFI van interrupt	
Signal type:	TTL levels
Operation:	Zero volts for ready condition
RFI to RSMS van inhibit	
Signal type:	Contact closure
Switch excitation:	+5 volts dc or ground
Operation:	Zero volts for inhibit receiver tuning
Center frequency display	
Cable and display unit supplied with RSMS van	
Electrical power	
The power cord for the RSMS van mates with a Hubbel 50-amp female connector (No. 9450). Two phases of the three-phase power are used.	
RSMS cable pin assignments are as shown.	

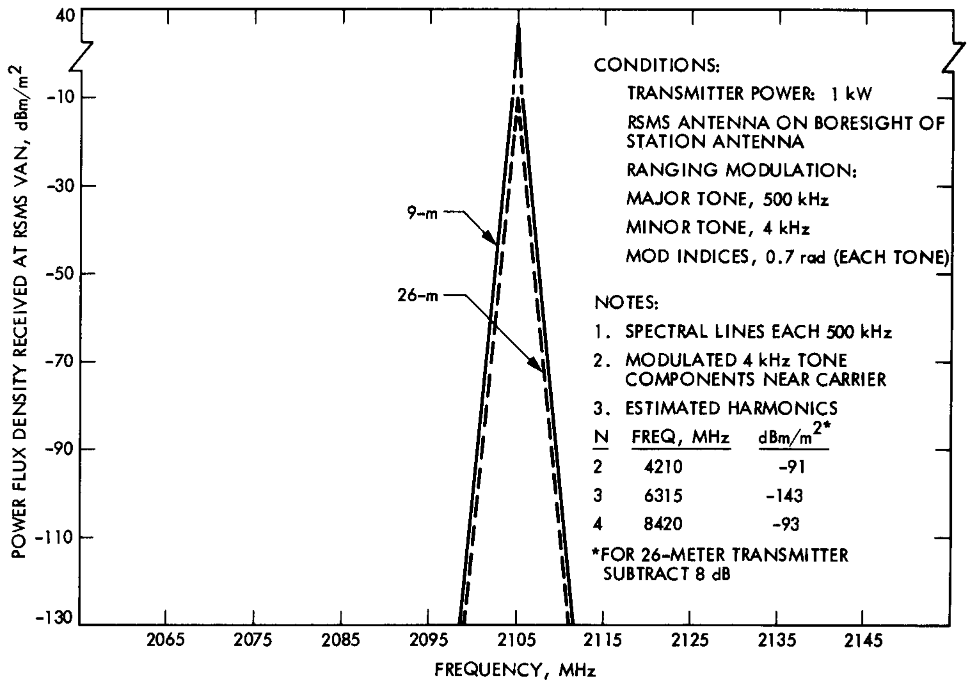

Fig. A-1. Expected emission envelope of STDN 9-meter and 26-meter transmitters

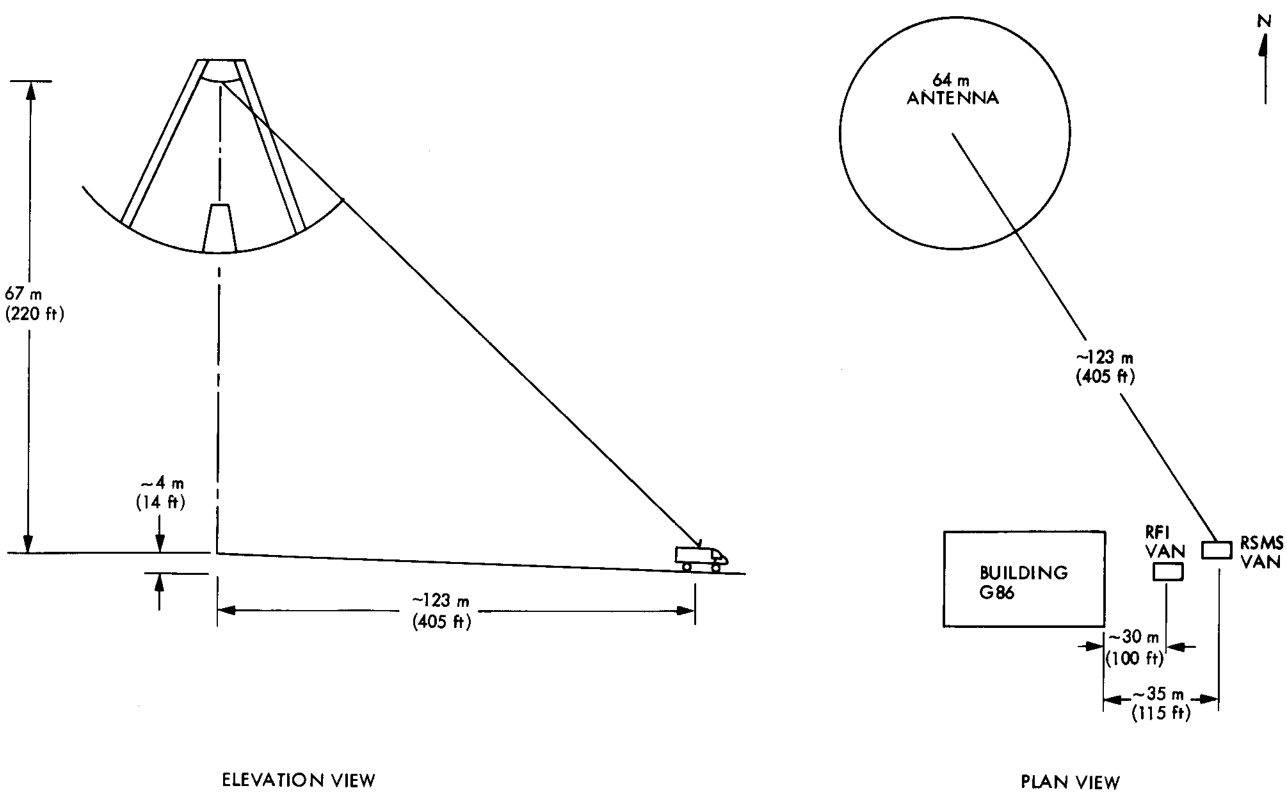

Fig. A-2. RMS van location at DSS 14

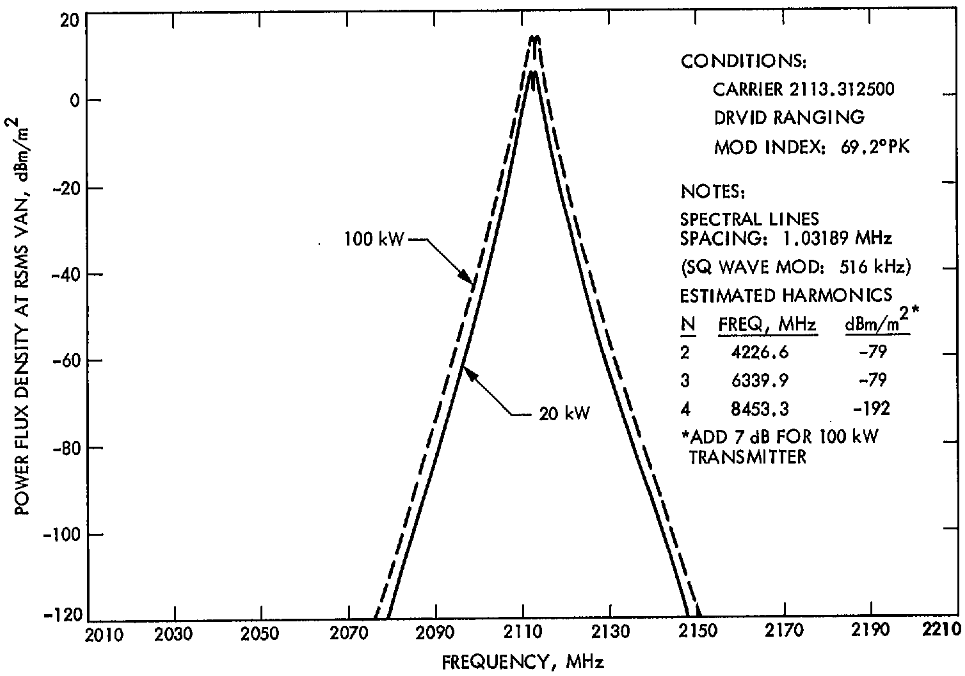

Fig. A-3. Expected emission envelopes of DSS 14 20- and 100-W transmitters

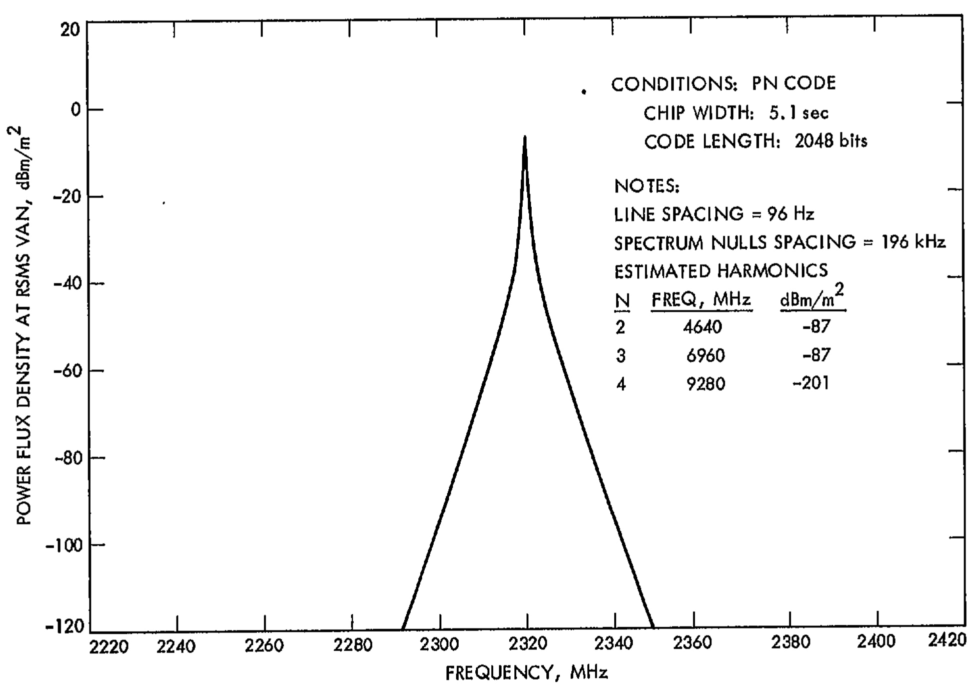

Fig. A-4. Expected emission envelope of DSS 14 400-kW S-band radar

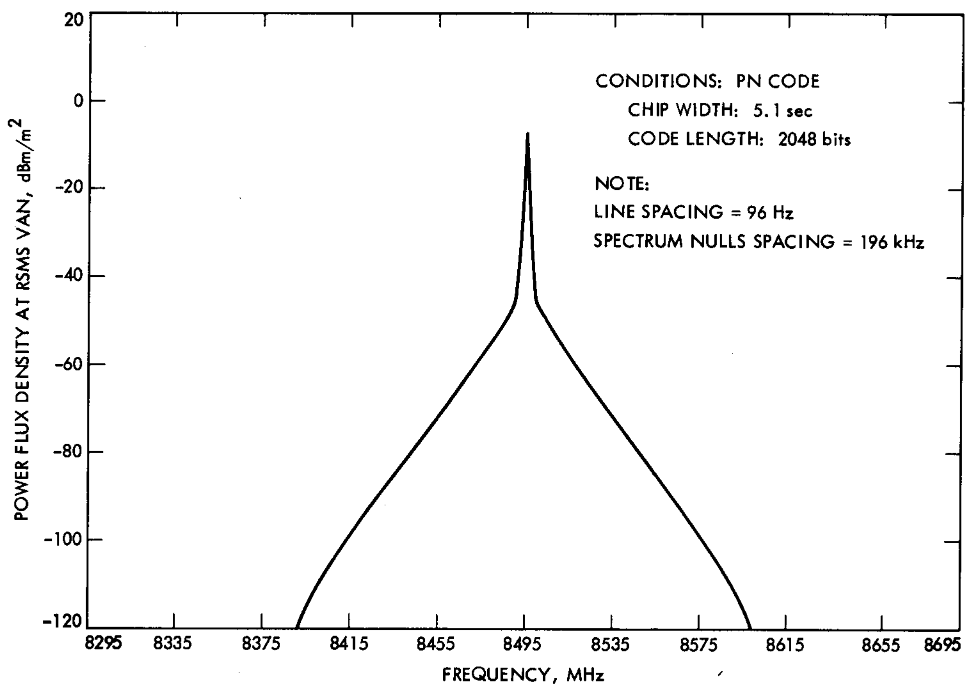

Fig. A-5. Expected emission envelope of DSS 14 400-kW X-band radar